WHAT IS CLAIMED IS:

1. An energy producing apparatus comprising:

compressor mechanism for compressing air and fuel;

an energy take-off device;

turbine mechanism for driving the compressor mechanism and the energy take-off device;

a main catalytic combustor disposed between an outlet of the compressor mechanism and an inlet of the turbine mechanism for combusting the air/fuel mixture compressed by the compressor mechanism and supplying the resulting products of combustion to the turbine side for driving the turbine mechanism, the main catalytic combustor having a volume sufficient for oxidizing enough of the fuel to achieve a predetermined turbine inlet temperature, and insufficient for oxidizing all of the fuel;

a secondary catalytic combustor disposed downstream of the turbine mechanism for receiving turbine exhaust gases and combusting at least some of the fuel therein that was not combusted by the main catalytic combustor; and

a heat exchanger arranged to receive turbine exhaust gases from the secondary catalytic combustor and for transferring heat therefrom to the compressed air/fuel being conducted to the main catalytic combustor, a passage extending from the turbine mechanism to the heat exchanger for conducting the exhaust gases being free of turbine mechanism.

2. The energy producing apparatus according to claim 1 further including an air inlet line for conducting air into the compressor mechanism, and a fuel inlet line for conducting fuel into the compressor separately from the air.

3. An energy producing apparatus comprising:

an energy conversion mechanism comprising a compressor side for compressing air/fuel,

and a turbine side for driving the compressor side;

an air supply conduit and a fuel supply conduit for conducting air and fuel separately into a compressor of the compressor side to be compressed and mixed therein, wherein only one stream of compressed air/fuel mixture exits the compressor side;

an electrical generator operably connected to the turbine side to be driven thereby for producing electrical energy;

a heat exchanger having a first passage for conducting the stream of compressed air/fuel mixture traveling from an outlet of the compressor side, and a second passage for conducting hot waste gas from an outlet of the turbine side in heat exchange relationship with the stream of compressed air/fuel mixture in the first passage;

a catalytic combustor disposed between an outlet of the first passage of the heat exchanger and an inlet of the turbine side for reacting compressed the air/fuel mixture received from the first passage prior to entry thereof into the turbine side; and

wherein the entire compressed stream of air/fuel mixture exiting the compressor side passes through the heat exchanger, and all of the fuel entering the catalytic combustor passes first through the compressor side and the heat exchanger during steady state operation of the apparatus.

4. An energy producing apparatus comprising:

compressor mechanism for compressing air and fuel;

an energy take-off device;

turbine mechanism for driving the compressor mechanism and the energy take-off device;

a main combustor disposed between an outlet of the compressor mechanism and an inlet of the turbine mechanism for combusting the air/fuel mixture compressed by the compressor

mechanism and supplying the resulting products of combustion to the turbine side for driving the turbine mechanism;

a secondary catalytic combustor disposed downstream of the turbine mechanism for receiving turbine exhaust gases; and

a heat exchanger arranged to receive turbine exhaust gases from the secondary catalytic combustor and for transferring heat therefrom to the compressed air/fuel being conducted to the main catalytic combustor.

5. The energy producing apparatus according to claim 4 further including an air inlet line for conducting air into the compressor mechanism, and a fuel inlet line for conducting fuel into the compressor separately from the air.

6. An energy producing apparatus comprising:

an energy conversion mechanism comprising a compressor side for compressing air/fuel, and a turbine side for driving the compressor side;

an air supply conduit and a fuel supply conduit for conducting air and fuel separately into a compressor of the compressor side to be compressed and mixed therein, wherein only one stream of compressed air/fuel mixture exits the compressor side;

an electrical generator operably connected to the turbine side to be driven thereby for producing electrical energy;

a heat exchanger having a first passage for conducting the stream of compressed air/fuel mixture traveling from an outlet of the compressor side, and a second passage for conducting hot waste gas from an outlet of the turbine side in heat exchange relationship with the stream of compressed air/fuel mixture in the first passage;

a combustor disposed between an outlet of the first passage of the heat exchanger and an

inlet of the turbine side; and

wherein the entire compressed stream of air/fuel mixture exiting the compressor side passes through the heat exchanger, and all of the fuel entering the combustor passes first through the compressor side and the heat exchanger during steady state operation.

7. An energy producing apparatus comprising:

compressor mechanism for compressing air and fuel;

an energy take-off device;

turbine mechanism for driving the compressor mechanism and the energy take-off device;

a main combustor disposed between an outlet of the compressor mechanism and an inlet of the turbine mechanism for combusting the air/fuel mixture compressed by the compressor mechanism and supplying the resulting products of combustion to the turbine side for driving the turbine mechanism, said main combustor designed to catalytically combust fuel;

a secondary catalytic combustor disposed downstream of the turbine mechanism for receiving turbine exhaust gases; and

a heat exchanger arranged to receive turbine exhaust gases from the secondary catalytic combustor and for transferring heat therefrom to the compressed air/fuel being conducted to the main catalytic combustor.

8. The energy producing apparatus according to claim 7 further including an air inlet line for conducting air into the compressor mechanism, and a fuel inlet line for conducting fuel into the compressor separately from the air.

9. An energy producing apparatus comprising:

an energy conversion mechanism comprising a compressor side for compressing air/fuel, and a turbine side for driving the compressor side;

an air supply conduit and a fuel supply conduit for conducting air and fuel separately into a compressor of the compressor side to be compressed and mixed therein, wherein only one stream of compressed air/fuel mixture exits the compressor side;

an electrical generator operably connected to the turbine side to be driven thereby for producing electrical energy;

a heat exchanger having a first passage for conducting the stream of compressed air/fuel mixture traveling from an outlet of the compressor side, and a second passage for conducting hot waste gas from an outlet of the turbine side in heat exchange relationship with the stream of compressed air/fuel mixture in the first passage;

a combustor disposed between an outlet of the first passage of the heat exchanger and an inlet of the turbine side, said combustor designed to catalytically combust fuel; and

wherein the entire compressed stream of air/fuel mixture exiting the compressor side passes through the heat exchanger, and all of the fuel entering the combustor passes first through the compressor side and the heat exchanger during steady state operation.

10. An energy producing apparatus comprising:

compressor mechanism for compressing air and fuel;

an energy take-off device;

turbine mechanism for driving the compressor mechanism and the energy take-off device;

a main combustor disposed between an outlet of the compressor mechanism and an inlet of the turbine mechanism for combusting the air/fuel mixture compressed by the compressor mechanism and supplying the resulting products of combustion to the turbine side for driving the turbine mechanism, said main combustor designed to catalytically combust fuel;

a secondary catalytic combustor disposed downstream of the turbine mechanism for

receiving turbine exhaust gases; and

a heat exchanger arranged to receive turbine exhaust gases from the secondary catalytic combustor and for transferring heat therefrom to the compressed air/fuel being conducted to the main catalytic combustor; and

wherein said turbine mechanism includes a turbine wheel, said energy take-off device is a motor-generator, said motor-generator includes a rotor, and said turbine wheel and said rotor are constrained to rotate together.

11. The energy producing apparatus according to claim 10/1 further including an air inlet line for conducting air into the compressor mechanism, and a fuel inlet line for conducting fuel into the compressor separately from the air.

12. An energy producing apparatus comprising:

an energy conversion mechanism comprising a compressor side for compressing air/fuel, and a turbine side for driving the compressor side;

an air supply conduit and a fuel supply conduit for conducting air and fuel separately into a compressor of the compressor side to be compressed and mixed therein, wherein only one stream of compressed air/fuel mixture exits the compressor side;

an electrical generator operably connected to the turbine side to be driven thereby for producing electrical energy;

a heat exchanger having a first passage for conducting the stream of compressed air/fuel mixture traveling from an outlet of the compressor side, and a second passage for conducting hot waste gas from an outlet of the turbine side in heat exchange relationship with the stream of compressed air/fuel mixture in the first passage;

a combustor disposed between an outlet of the first passage of the heat exchanger and an

inlet of the turbine side, said combustor designed to catalytically combust fuel;

wherein the entire compressed stream of air/fuel mixture exiting the compressor side passes through the heat exchanger, and all of the fuel entering the combustor passes first through the compressor side and the heat exchanger during steady state operation; and

wherein said turbine side includes a turbine wheel, said electric generator includes a rotor, and said turbine wheel and said rotor are constrained to rotate together.

13. An energy producing apparatus comprising:

compressor mechanism for compressing air and fuel;

an energy take-off device;

turbine mechanism for driving the compressor mechanism and the energy take-off device;

a main combustor disposed between an outlet of the compressor mechanism and an inlet of the turbine mechanism for combusting the air/fuel mixture compressed by the compressor mechanism and supplying the resulting products of combustion to the turbine side for driving the turbine mechanism;

a secondary catalytic combustor disposed downstream of the turbine mechanism for receiving turbine exhaust gases;

a heat exchanger arranged to receive turbine exhaust gases from the secondary catalytic combustor and for transferring heat therefrom to the compressed air/fuel being conducted to the main catalytic combustor.; and

wherein said main combustor defines a substantially annular main combustion chamber having a main combustion chamber annular outer radius, said secondary catalytic combustor has a substantially annular shape and a secondary catalytic combustor inner annular radius, and said secondary catalytic combustor inner annular radius is greater than said main combustion chamber

annular outer radius.

14. The apparatus of claim 13 wherein said heat exchanger has a substantially annular shape and a heat exchanger inner annular radius, and said heat exchanger inner annular radius is substantially the same as said secondary catalytic combustor inner annular radius.

15. The apparatus of claim 13, wherein gas flows generally axially along one first axial direction in the main combustor and gas flows generally axially in the secondary catalytic combustor in a second axial direction which is opposite said first axial direction.

16. The energy producing apparatus according to claim 13 further including an air inlet line for conducting air into the compressor mechanism, and a fuel inlet line for conducting fuel into the compressor separately from the air.

17. An energy producing apparatus comprising:

an energy conversion mechanism comprising a compressor side for compressing air/fuel, and a turbine side for driving the compressor side;

an air supply conduit and a fuel supply conduit for conducting air and fuel separately into a compressor of the compressor side to be compressed and mixed therein, wherein only one stream of compressed air/fuel mixture exits the compressor side;

an electrical generator operably connected to the turbine side to be driven thereby for producing electrical energy;

a heat exchanger having a first passage for conducting the stream of compressed air/fuel mixture traveling from an outlet of the compressor side, and a second passage for conducting hot waste gas from an outlet of the turbine side in heat exchange relationship with the stream of compressed air/fuel mixture in the first passage;

a combustor disposed between an outlet of the first passage of the heat exchanger and an

inlet of the turbine side;

wherein the entire compressed stream of air/fuel mixture exiting the compressor side passes through the heat exchanger, and all of the fuel entering the combustor passes first through the compressor side and the heat exchanger during steady state operation; and

wherein said combustor defines a substantially annular main combustion chamber.

18. The apparatus of claim 17 wherein said heat exchanger has a substantially annular shape and a heat exchanger inner annular radius, said main annular main combustor chamber has an annular main combustion chamber annular outer radius, and said heat exchanger inner annular radius is larger than said main combustion chamber annular outer radius.

19. The apparatus of claim 17, wherein gas flows generally axially along one first axial direction in said main combustor and gas flows generally axially in said heat exchanger in a second axial direction which is opposite said first axial direction.

20. An method of producing energy comprising the steps of:

compressing air and fuel using a compressor mechanism;

taking of energy using an energy take-off device;

driving the compressor mechanism and the energy take-off device using a turbine mechanism;

combusting the air/fuel mixture compressed by the compressor mechanism and supplying the resulting products of combustion to the turbine side for driving the turbine mechanism using a main combustor disposed between an outlet of the compressor mechanism and an inlet of the turbine mechanism;

receiving turbine exhaust gases using a secondary catalytic combustor disposed downstream of the turbine mechanism;

receiving turbine exhaust gases from the secondary catalytic combustor and transferring heat therefrom to the compressed air/fuel being conducted to the main catalytic combustor using a heat exchanger; and

wherein said main combustor defines a substantially annular main combustion chamber having a main combustion chamber annular outer radius, said secondary catalytic combustor has a substantially annular shape and a secondary catalytic combustor inner annular radius, and said secondary catalytic combustor inner annular radius is greater than said main combustion chamber annular outer radius.

21. The method of claim 20 wherein said heat exchanger has a substantially annular shape and a heat exchanger inner annular radius, and said heat exchanger inner annular radius is substantially the same as said secondary catalytic combustor inner annular radius.

22. The method of claim 20, wherein gas flows generally axially along one first axial direction in the main combustor and gas flows generally axially in the secondary catalytic combustor in a second axial direction which is opposite said first axial direction.

23. The method of claim 20 further including conducting air into the compressor mechanism in an air inlet line, and conducting fuel into the compressor separately from the air using a fuel inlet line.

24. An method of producing energy comprising the steps of:

compressing air/fuel, and a turbine side for driving the compressor side using an energy conversion mechanism comprising a compressor side;

conducting air and fuel separately into a compressor of the compressor side to be compressed and mixed therein, wherein only one stream of compressed air/fuel mixture exits the compressor side;

producing electrical energy using in an electrical generator operably connected to and driven by the turbine side;

conducting hot waste gas from an outlet of the turbine side in heat exchange relationship with the stream of compressed air/fuel mixture in a first passage, in a heat exchanger;

combusting fuel in a combustor disposed between an outlet of the first passage of the heat exchanger and an inlet of the turbine side;

wherein the entire compressed stream of air/fuel mixture exiting the compressor side passes through the heat exchanger, and all of the fuel entering the combustor passes first through the compressor side and the heat exchanger during steady state operation; and

wherein said combustor defines a substantially annular main combustion chamber.

25. The method of claim 24 wherein said heat exchanger has a substantially annular shape and a heat exchanger inner annular radius, said main annular main combustor chamber has an annular main combustion chamber annular outer radius, and said heat exchanger inner annular radius is larger than said main combustion chamber annular outer radius.

26. The method of claim 24, wherein gas flows generally axially along one first axial direction in said main combustor and gas flows generally axially in said heat exchanger in a second axial direction which is opposite said first axial direction.

27. A turbogenerator system, comprising:

a turbine;

a compressor;

a motor/generator;

a common shaft on which the turbine, compressor and motor/generator are mounted for rotation;

a primary combustor downstream of said compressor, said primary combustor having an exhaust gas outlet applied to the turbine to rotate the common shaft, the compressor and motor/generator;

a source of fuel for providing fuel to the primary combustor;

a catalytic reactor downstream of said turbine for reducing unburned hydrocarbons in said exhaust gases;

a recuperator for transferring heat from said exhaust gases to compressed gas applied by said compressor to said primary combustor;

a DC bus connected between said motor/generator and a load; and

a power controller for independently controlling the speed of said common shaft, an operating temperature of said turbogenerator and the voltage on said DC bus.

28. The turbogenerator system of claim 27 wherein said primary combustor is a flame combustor.

29. The turbogenerator system of claim 28 wherein said compressor compresses air which is applied, together with fuel from said source of fuel, to said primary combustor.

30. The turbogenerator system of claim 28 wherein said compressor receives from said source of fuel which is compressed together with air in said compressor to form a compressed air fuel mixture applied to said primary combustor.

31. The turbogenerator system of claim 27 wherein said primary combustor is a second catalytic reactor.

32. The turbogenerator system of claim 31 wherein said compressor compresses air which is applied, together with fuel from said source of fuel, to said primary combustor.

33. The turbogenerator system of claim 31 wherein said compressor receives from said

source of fuel which is compressed together with air in said compressor to form a compressed air fuel mixture applied to said primary combustor.

34. The turbogenerator system of claim 28 or 29 or 30 or 31 or 32 or 33 wherein said power controller further comprises:

a bi-directional generator power converter connected between said motor/generator and said DC bus for converting AC power from said motor/generator for application to said DC bus and for converting DC power from said DC bus for application to said motor/generator;

a speed control loop responsive to a measured value related to a rotational speed of said common shaft and the turbine, compressor and motor/generator mounted thereon for controlling said rotation speed at a predetermined speed set point by operating said bi-directional generator power converter to apply power from said motor/generator to said DC bus and from said DC bus to said motor/generator.

35. The turbogenerator system of claim 34 wherein said speed control loop is responsive to a value of power applied to the load for determining said speed set point.

36. The turbogenerator system of claim 34 wherein said power controller further comprises:

a temperature control loop responsive to a measured operating temperature of said turbogenerator system for controlling said operating temperature to a predetermined temperature set point by controlling the flow of fuel from said fuel source to said primary combustor.

37. The turbogenerator of claim 36 wherein said temperature control loop is responsive to said rotational speed for determining said temperature set point.

38. The turbogenerator system of claim 36 wherein said power controller further comprises:

a bi-directional load power converter connected between said DC bus and said load for converting DC power from DC bus for application to said load and for converting power from said load to said DC bus;

a bus voltage control loop responsive to a measured value related to a voltage of said DC bus for controlling said voltage at a predetermined voltage set point by applying power from said DC bus to said load and from said load to said DC bus.

39. The turbogenerator system of claim 38 further comprising:

a dynamic brake resistor selectively applied by said bus voltage control loop to said DC bus to remove power therefrom.

40. The turbogenerator system of claim 39 further comprising:

an energy storage device; and

a bi-directional batter power converter responsive to said bus voltage control loop for selectively applying power from said energy storage device to said DC bus and from said DC bus to said energy storage device.

41. A turbogenerator system, comprising:

a turbine;

a compressor;

a motor/generator;

a common shaft on which the turbine, compressor and motor/generator are mounted for rotation;

a primary combustor downstream of said compressor, said primary combustor having an exhaust gas outlet applied to the turbine to rotate the common shaft, the compressor and motor/generator;

a source of fuel for providing fuel to the primary combustor;

a catalytic reactor downstream of said turbine for reducing unburned hydrocarbons in said exhaust gases; and

a recuperator for transferring heat from said exhaust gases to compressed gas applied by said compressor to said primary combustor.

42. The turbogenerator system of claim 41 wherein said primary combustor is a flame combustor.

43. The turbogenerator system of claim 42 wherein said compressor compresses air which is applied, together with fuel from said source of fuel, to said primary combustor.

44. A turbogenerator system, comprising:

a turbine;

a compressor;

a motor/generator;

a common shaft on which the turbine, compressor and motor/generator are mounted for rotation;

a primary combustor downstream of said compressor, said primary combustor having an exhaust gas outlet applied to the turbine to rotate the common shaft, the compressor and motor/generator;

a source of fuel for providing fuel to the primary combustor;

a catalytic reactor downstream of said turbine for reducing unburned hydrocarbons in said exhaust gases;

a recuperator for transferring heat from said exhaust gases to compressed gas applied by said compressor to said primary combustor; and

a flame burner.

45. The system of claim 44 wherein said flame burner is positioned in series with second catalytic reactor.

46. The system of claim 44 wherein said flame burner is positioned in parallel with second catalytic reactor.

47. The system of claim 44 further comprising a source of heat for heating said catalytic reactor other than via conversion of fuel in said catalytic reactor.

48. The system of claim 47 wherein said source of heat includes one of an electrical heater and a flame source.

49. The system of claim 47 further comprising a control mechanism designed to discontinue providing heat from said source of heat to said catalytic reactor when said catalytic reactor reaches a specified temperature.

50. The system of claim 44 wherein said system is designed to run in a condition where temperature of gas flowing in said system is increased by said compressor, then is increased further in said recuperator, then is increased further in said primary combustor, wherein said primary combustor is a catalytic reactor, then is reduced during expansion through said turbine, then is increased catalytic reactor downstream of said turbine, and then is decreased in said recuperator.

51. The system of claim 44 wherein gas temperature downstream of said primary combustor is higher than gas temperature downstream of said catalytic reactor.

52. The system of claim 44 wherein gas temperature entering said primary combustor is lower than gas temperature entering said catalytic reactor.

53. The system of claim 44 wherein said compressor is designed to compress gas to

between three and six times compressor inlet pressure.

54. The system of claim 44 wherein said system is designed to operate at a maximum system temperature no higher than 1800° F.

55. The system of claim 44 wherein said system is designed to operate at a maximum system temperature no higher than 1400° F.

56. The system of claim 54 or 55 wherein said maximum temperature occurs in said primary combustor.

57. The system of claim 44 wherein said system is designed to generate a temperature at the entrance of said catalytic reactor between 800° F and 1200 ° F.

58. A method of operating a turbogenerator system, comprising the steps of:

increasing gas temperature by compressing it in a compressor;

further increasing temperature of said gas in a heat exchanger downstream of said compressor;

further increasing temperature of said gas by converting chemical energy to heat in a catalytic reactor downstream of the heat exchanger;

reducing the temperature of said gas by flowing it through a turbine;

increasing the temperature of the gas downstream of said turbine by converting chemical energy to heat in a second catalytic reactor; and

decreasing temperature of said gas by flowing said gas through a heat exchanger downstream of said second catalytic converter.